

Please type a plus sign (+) inside this box → ☐

PTO/SB/05 (1/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. **DN37882YE**

First Inventor or Application Identifier **Robert C. Meier**

Title **Radio Frequency Local Area Network**

Express Mail Label No. **EI075597159US**

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. ☒ * Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification [Total Pages **151**]
(preferred arrangement set forth below)
 - Descriptive title of the invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the invention
 - Brief Summary of the invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets **2**]
4. Oath or Declaration [Total Pages **7**]
 - a. ☐ Newly executed (original or copy)
 - b. ☒ Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
 - i. ☐ **DELETION OF INVENTOR(S)**
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).
5. ☒ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered to be part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
 - a. ☐ Computer Readable Copy
 - b. ☐ Paper Copy (identical to computer copy)
 - c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 C.F.R. § 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☐ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
 - * Small Entity
14. ☐ Statement(s) ☐ Statement filed in prior application, Status still proper and desired (PTO/SB/09-12)
15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. ☐ Other:

* A new statement is required to be entitled to pay small entity fees, except where one has been filed in a prior application and is being relied upon.

17. If a **CONTINUING APPLICATION**, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: **08 / 395,555**
Prior application information: Examiner **P. Huang** Group / Art Unit: **2317**

18. CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label or ☒ Correspondence address below
(Insert Customer No. or Attach bar code label here)

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Name (Print/Type)	Gary R. Stanford	Registration No. (Attorney/Agent)	35,689
Signature	<i>Gary R. Stanford</i>	Date	4/14/98

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

<h2 style="margin: 0;">FEE TRANSMITTAL</h2> <p style="font-size: small; margin: 5px 0;">Note: Effective October 1, 1997. Patent fees are subject to annual revision.</p>	Complete if Known												
TOTAL AMOUNT OF PAYMENT (\$ 790.00)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Application Number</td><td>Unassigned</td></tr> <tr><td>Filing Date</td><td>4/14/98</td></tr> <tr><td>First Named Inventor</td><td>Robert C. Meier</td></tr> <tr><td>Group Art Unit</td><td>2317</td></tr> <tr><td>Examiner Name</td><td>P. Huang</td></tr> <tr><td>Attorney Docket Number</td><td>DN37882YE</td></tr> </table>	Application Number	Unassigned	Filing Date	4/14/98	First Named Inventor	Robert C. Meier	Group Art Unit	2317	Examiner Name	P. Huang	Attorney Docket Number	DN37882YE
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METHOD OF PAYMENT (check one)	FEE CALCULATION (continued)																																																																																																																																																																																				
<p>1. <input type="checkbox"/> The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:</p> <p>Deposit Account Number 01-0660</p> <p>Deposit Account Name _____</p> <p><input checked="" type="checkbox"/> Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17 <input type="checkbox"/> Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance</p> <p>2. <input checked="" type="checkbox"/> Payment Enclosed: <input checked="" type="checkbox"/> Check <input type="checkbox"/> Money Order <input type="checkbox"/> Other</p>	<h3>3. 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SUBMITTED BY			Complete (if applicable)	
Typed or Printed Name	Gary R. Stanford		Reg. Number	35,689
Signature		Date	4/14/98	Deposit Account User ID
				01-0660

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Attorney Docket No. DN37882YE)

In the Application of:
Meier et al.

Serial No.: Unassigned

Filed: Herewith

For: RADIO FREQUENCY LOCAL
AREA NETWORK

§ Group Art Unit:

§ Examiner:

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CERTIFICATE OF EXPRESS MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to addressee" Service under 37 C.F.R. Sec. 1.10 addressed to: Box: Patent Application, Assistant Commissioner for Patents, Washington, D.C. 20231, on April 14, 1998.

Express Mailing Label No.: EI075597159US

Deena Beasley
Deena Beasley

PRELIMINARY AMENDMENT

Box: Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In re the above-identified patent application, which is a continuation application of pending parent application (Serial No. 08/395,555 filed February 28, 1995), filed pursuant to 37 C.F.R. 1.53, please enter the following preliminary amendment.

In the Specification:

On page 1, line 15, after the title, please cancel the present section headed "CROSS-REFERENCE TO RELATED APPLICATIONS" and substitute the following new section:

-- CROSS-REFERENCE TO RELATED APPLICATIONS

The present case is a continuation of U.S. Serial No. 08/395,555 filed February 28, 1995, which is a continuation of U.S. Serial No. 08/255,848 filed June 8, 1994 by Meier et al.

00060287-041498

09060287-04198
061740-28299060

(Attorney Docket Nos. 10523US01 and DN37882YC) which is a continuation of U.S. Serial No. 07/970,411, filed November 2, 1992 by Meier et al. (Attorney Docket Nos. 92P767 and DN37882YB) which is a continuation in part of U.S. Serial No. 07/968,990, filed October 30, 1992 (Attorney Docket Nos. 92P758 and DN37882YA), which is itself a continuation in part of a pending application of Meier et al., U.S. Serial No. 07/769,425, filed October 1, 1991 (Attorney Docket Nos. 91P668 and DN37882). The pending application U.S. Serial No. 08/968,990 is also a continuation in part of pending PCT application of Mahany et al., Serial No. PCT/US92/08610, filed October 1, 1992 (Attorney Docket Nos. 92P661 and DN378882Y).

The entire disclosures of each of these applications including the drawings and appendices are incorporated herein.--

In the Claims:

Please cancel claims 1 through 14 without prejudice.

Please add the following new claims:

--15. A communication network supporting wireless communication of messages, said communication network comprising:

a first terminal node having a wireless receiver operable in a normal state;

a second terminal node having a wireless receiver operable in a power saving state;

an access point that attempts to immediately deliver messages destined for the first terminal node;

--20. The communication network of claim 19 wherein the awake time window occurs an offset time following the one of the received beacons.--

--21. The communication network of claim 17 wherein the second terminal node has a wireless transmitter that is used to request the message awaiting delivery.--

--22. The communication network of claim 19 wherein the second terminal node has a wireless transmitter that is used to request that the message awaiting delivery be delivered during the awake time window.--

--23. The communication network of claim 20 wherein the second terminal node has a wireless transmitter that is used to request that the message awaiting delivery be delivered during the awake time window at the offset time, wherein the awake time window and the offset time are communicated with the request.--

--24. The communication network of claim 15 wherein the second terminal node communicates to the access point an indication of whether the second terminal node operates in the power saving state.--

--25. The communication network of claim 17 wherein the access point queues the messages awaiting delivery, and removes from the queue those of the messages awaiting delivery where delivery is unsuccessful.--

--26. The communication network of claim 25 wherein the messages awaiting delivery remain in the queue until delivery is successful or until a predetermined number of the beacons occur wherein delivery is unsuccessful.--

--27. The communication network of claim 17 wherein the second terminal node synchronizes operation of its wireless receiver to receive the beacons from the access point even when one or more of the beacons from the access point have not been received.--

--28. The communication network of claim 15 wherein the second terminal node comprises a battery-powered, roaming device.--

--29. The communication network of claim 28 wherein the access point participates in spanning tree routing to support the battery-powered, roaming device.—

--30. A communication network supporting wireless communication of messages, said communication network comprising:

a first terminal node operating in a first state;

a second terminal node operating in a second state in which attempts are made to minimize power consumption by the wireless receiver

a bridging node having a wireless transceiver to support wireless communication to the first and second terminal nodes;

the bridging node attempts to deliver messages destined for the second terminal node by transmitting at predetermined intervals beacons that identify a message awaiting delivery;

the second terminal node synchronizing operation of its wireless receiver to receive the beacons from the bridging node and determining from the received beacons that it has a message awaiting delivery and responding to an awaiting message by directing further operation of its wireless receiver to receive the message; and

the bridging node delivering messages to the first terminal node without requiring the first terminal node to determine from the beacons that it has messages awaiting delivery.--

--31. The communication network of claim 30 wherein the second terminal node directs further operation of its receiver to receive the message during a time period that follows one of the received beacons.--

--32. The communication network of claim 31 wherein the time period immediately follows the one of the received beacons.--

--33. The communication network of claim 31 wherein the time period follows the one of the received beacons during an awake time window.--

--34. The communication network of claim 34 wherein the awake time window occurs an offset time following the one of the received beacons.--

Remarks

Claims 15 - 26 are now pending in this application. These claims correspond to allowed claims in the parent case.

Respectfully submitted,

Date: April 14, 1998

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Attorney Docket Nos. 92 P 767; DN37882YB)

TITLE: RADIO FREQUENCY LOCAL AREA NETWORK

CROSS-REFERENCE TO RELATED APPLICATION

5 The present application is a continuation in part
of a pending application of Meier et al., U.S. Serial
No. _____, filed October 30, 1991 (Attorney
Docket Nos. 92 P 758; DN37882YA), which is itself a
continuation in part of a pending application of Meier
et al., U.S. Serial No. 07/769,425, filed October 1,
1991 (Attorney Docket Nos. 91 P 668; DN37882). The
10 pending application U.S. Serial No. 07/769,425 is also
a continuation in part of pending PCT application of
Mahany et al., Serial No. PCT/US92/08610, filed
October 1, 1992 (Attorney Docket Nos. 92 P 661;
DN37882Y).

15 The entire disclosures of each of these
pending applications including the drawings and
appendices are incorporated herein by reference as if
set forth fully in this application.

20 Appendix B is a microfiche appendix containing a
list of the program modules (also included as Appendix
A) and the program modules themselves which comprise
an exemplary computer program listing of the source
code used by the network controllers and intelligent
base transceivers of the present invention. The
25 microfiche appendix has ten (10) total microfiche
sheets and six hundred two (602) total frames.

BACKGROUND OF THE INVENTION

30 In a typical radio data communication system
having one or more host computers and multiple RF
terminals, communication between a host computer and

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an RF terminal is provided by one or more base stations. Depending upon the application and the operating conditions, a large number of these base stations may be required to adequately serve the system. For example, a radio data communication system installed in a large factory may require dozens of base stations in order to cover the entire factory floor.

In earlier RF (Radio Frequency) data communication systems, the base stations were typically connected directly to a host computer through multi-dropped connections to an Ethernet communication line. To communicate between an RF terminal and a host computer, in such a system, the RF terminal sends data to a base station and the base station passes the data directly to the host computer. Communicating with a host computer through a base station in this manner is commonly known as hopping. These earlier RF data communication systems used a single-hop method of communication.

In order to cover a larger area with an RF data communication system and to take advantage of the deregulation of the spread-spectrum radio frequencies, later-developed RF data communication systems are organized into layers of base stations. As in earlier RF data communications systems, a typical system includes multiple base stations which communicate directly with the RF terminals and the host computer. In addition, the system also includes intermediate stations that communicate with the RF terminals, the multiple base stations, and other intermediate stations. In such a system, communication from an RF terminal to a host computer may be achieved, for example, by having the RF terminal send data to an intermediate station, the intermediate station send

the data to a base station, and the base station send the data directly to the host computer. Communicating with a host computer through more than one station is commonly known as a multiple-hop communication system.

5 Difficulties often arise in maintaining the integrity of such multiple-hop RF data communication systems. The system must be able to handle both wireless and hard-wired station connections, efficient dynamic routing of data information, RF
10 terminal mobility, and interference from many different sources.

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SUMMARY OF THE INVENTION

The present invention solves many of the problems inherent in a multiple-hop data communication system. The present invention comprises an RF Local-Area Network capable of efficient and dynamic handling of data by routing communications between the RF Terminals and the host computer through a network of intermediate base stations.

In one embodiment of the present invention, the RF data communication system contains one or more host computers and multiple gateways, bridges, and RF terminals. Gateways are used to pass messages to and from a host computer and the RF Network. A host port is used to provide a link between the gateway and the host computer. In addition, gateways may include bridging functions and may pass information from one RF terminal to another. Bridges are intermediate relay nodes which repeat data messages. Bridges can repeat data to and from bridges, gateways and RF terminals and are used to extend the range of the gateways.

The RF terminals are attached logically to the host computer and use a network formed by a gateway and the bridges to communicate with the host computer. To set up the network, an optimal configuration for conducting network communication spanning tree is created to control the flow of data communication. To aid understanding by providing a more visual description, this configuration is referred to hereafter as a "spanning tree" or "optimal spanning tree".

Specifically, root of the spanning tree are the gateways; the branches are the bridges; and non-bridging stations, such as RF terminals, are the leaves of the tree. Data are sent along the branches

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of an RF data communication system incorporating the RF local-area network of the present invention.

5 FIG. 2 is a flow diagram illustrating a bridging node's construction and maintenance of the spanning tree.

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DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a functional block diagram of an RF data communication system. In one embodiment of the present invention, the RF data communication system has a host computer 10, a network controller 14 and bridges 22 and 24 attached to a data communication link 16. Also attached to the data communication link 16 is a gateway 20 which acts as the root node for the spanning tree of the RF data network of the present invention. A bridge 42 is attached to the gateway 20 through a hard-wired communication link and bridges 40 and 44 are logically attached to gateway 20 by two independent RF links. Additional bridges 46, 48, 50 and 52 are also connected to the RF Network and are shown in the FIG. 1. Note that, although shown separate from the host computer 10, the gateway 20 (the spanning tree root node) may be part of host computer 10.

The FIG. 1 further shows RF terminals 100 and 102 attached to bridge 22 via RF links and RF terminal 104 attached to bridge 24 via an RF link. Also, RF terminals 106, 108, 110, 112, 114, 116, 118, and 120 can be seen logically attached to the RF Network through their respective RF links. The RF terminals in FIG. 1 are representative of non-bridging stations. In alternate embodiments of the present invention, the RF Network could contain any type of device capable of supporting the functions needed to communicate in the RF Network such as hard-wired terminals, remote printers, stationary bar code scanners, or the like. The RF data communication system, as shown in FIG. 1, represents the configuration of the system at a discrete moment in time after the initialization of the system. The RF links, as shown, are dynamic and subject to change. For example, changes in the

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The optimal spanning tree, which provides the data pathways throughout the communication system, is stored and maintained by the network as a whole. Each node in the network stores and modifies information which specifies how local communication traffic should flow. Optimal spanning trees assure efficient, adaptive (dynamic) routing of information without looping.

To initialize the RF data communication system, the gateway 20 and the other nodes are organized into an optimal spanning tree rooted at the gateway 20. To form the optimal spanning tree, in the preferred embodiment the gateway 20 is assigned a status of ATTACHED and all other bridges are assigned the status UNATTACHED. The gateway 20 is considered attached to the spanning tree because it is the root node. Initially, all other bridges are unattached and lack a parent in the spanning tree. At this point, the attached gateway node 20 periodically broadcasts a specific type of polling packet referred to hereafter as "HELLO packets". The HELLO packets can be broadcast using known methods of communicating via radio frequency (RF) link or via a direct wire link.

In the preferred embodiment of the present invention, the RF link is comprised of spread-spectrum transmissions using a polling protocol. Although a polling protocol is preferred, a carrier-sense multiple-access (CSMA), busy-tone, or any other protocol might also manage the communication traffic on the RF link.

HELLO packets contain 1) the address of the sender, 2) the hopping distance that the sender is from the root, 3) a source address, 4) a count of nodes in the subtree which flow through that bridge, and 5) a list of system parameters. Each node in the network is assigned a unique network service address and a node-type identifier to distinguish between different nodes and different node types. The distance of a node from the root node is measured in hops times the bandwidth of each hop. The gateway root is considered to be zero hops away from itself.

FIG. 2 is a flow diagram illustrating a bridge's participation in the construction and maintenance of the spanning tree. At a block 201, the bridge begins the local construction of the spanning tree upon power-up. Next, at a block 203, the bridge enters the UNATTACHED state, listening for HELLO packets (also referred to as HELLO messages herein) that are broadcast.

By listening to the HELLO messages, bridges can learn which nodes are attached to the spanning tree. At a block 205, the bridge responds to a HELLO packet received by sending an ATTACH.request packet to the device that sent the received HELLO packet. The ATTACH.request packet is thereafter forwarded towards and to the root node which responds by sending an ATTACH.response packet back down towards and to the bridge.

5 The bridge awaits the ATTACH.response packet at
a block 207. Upon receipt of the ATTACH.response
packet, at a block 209, the bridge enters an ATTACHED
state. Thereafter, at a block 211, the bridge begins
periodically broadcasting HELLO packets and begins
forwarding or relaying packets received.
Specifically, between HELLO packet broadcasts, the
bridge listens for HELLO, DATA, ATTACH.request and
ATTACH.response packets broadcast by other devices in
10 the communication network. Upon receiving such a
packet, the bridge branches to a block 213. At the
block 213, if the bridge detects that it has become
detached from the spanning tree the bridge will branch
back to the block 203 to establish attachment. Note
15 that although the illustration in FIG. 2 places block
213 immediately after the block 211, the bridges
functionality illustrated in block 213 is actually
distributed throughout the flow diagram.

20 If at the block 213 detachment has not occurred,
at a block 214, the bridge determines if the received
packet is a HELLO packet. If so, the bridge analyzes
the contents of the HELLO packet at a block 215 to
determine whether to change its attachment point in
the spanning tree. In a preferred embodiment, the
25 bridge attempts to maintain attachment to the spanning
tree at the node that is logically closest to the root
node.

30 The logical distance, in a preferred embodiment,
is based upon the number of hops needed to reach the
root node and the bandwidth of those hops. The
distance the attached node is away from the root node
is found in the second field of the HELLO message that
is broadcast. In another embodiment of the present
invention, the bridges consider the number of nodes
35 attached to the attached node as well as the logical

more fully below. As a result of the backward learning, once the root node receives the ATTACH.request packet, an ATTACH.response packet can be sent through the spanning tree to the bridge requesting attachment.

After attaching to an attached node, the newly attached bridge (the child) must determine its distance from the root node. To arrive at the distance of the child from the root node, the child adds the broadcast distance of its parent from the root node to the distance of the child from its parent. In the preferred embodiment, the distance of a child from its parent is based on the bandwidth of the data communication link. For example, if the child attaches to its parent via a hard-wired link (data rate 26,000 baud), then the distance of that communication link might equal, for example, one hop. However, if the child attaches to its parent via an RF link (data rate 9600 baud), then the distance of that communication link might correspondingly be equal 3 hops. The number of the hop corresponds directly to the communication speed of the link. This may not only take into consideration baud rate, but also such factors as channel interference.

Initially, only the root gateway node 20 is broadcasting HELLO messages and only nodes 40, 42 and 44 are within range of the HELLO messages broadcast by the gateway. Therefore, after the listening period has expired, nodes 40, 42 and 44 request attachment to the gateway node 20. The unattached nodes 40, 42, and 44 send ATTACH.request packets and the attached gateway node 20 acknowledges the ATTACH.request packets with local ATTACH.confirm packets. The newly attached bridges are assigned the status ATTACHED and begin broadcasting their own HELLO

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reaches the gateway root node, the gateway root node returns an end-to-end ATTACH.confirm packet.

5 After the spanning tree is initialized, the RF terminals listen for periodically broadcasted Hello packets to determine which attached nodes are in range. After receiving HELLO messages from attached nodes, an RF terminal responding to an appropriate poll sends an ATTACH.request packet to attach to the node logically closest to the root. For example, RF
10 terminal 110 is physically closer to node 44. However, node 44 is three hops, via an RF link, away from the gateway root node 20 and node 42 is only one hop, via a hard-wired link, away from the gateway root node 20. Therefore, RF terminal 110, after hearing
15 HELLO messages from both nodes 42 and 44, attaches to node 42, the closest node to the gateway root node 20. Similarly, RF terminal 114 hears HELLO messages from nodes 48 and 50. Nodes 48 and 50 are both four hops away from the gateway root node 20. However, node 48
20 has two RF terminals 110 and 112 already attached to it while node 50 has only one RF terminal 116 attached to it. Therefore, RF terminal 114 will attach to node 50, the least busy node of equal distance to the gateway root node 20. Attaching to the least busy
25 node proves to be the most efficient practice when the communication system has little overlap in the RF communication regions. In another embodiment, however, instead of attaching to the least busy node of equal distance to the gateway root node 20, the
30 attachment is established with the busiest node.

The attached node acknowledges the ATTACH.request and sends the ATTACH.request packet to the gateway root node. Then, the gateway root node returns an end-to-end ATTACH.confirm packet. In this manner, the
35 end-to-end ATTACH.request functions as a discovery

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The RF links among the RF terminals, the bridges, and the gateway are often lost. Therefore, a connection-oriented data-link service is used to maintain the logical node-to-node links. In the absence of network traffic, periodic messages are sent and received to ensure the stability of the RF link. As a result, the loss of a link is quickly detected and the RF Network can attempt to establish a new RF link before data transmission from the host computer to an RF terminal is adversely affected.

Communication between terminals and the host computer is accomplished by using the resulting RF Network. To communicate with the host computer, an RF terminal sends a data packet in response to a poll from the bridge closest to the host computer. Typically, the RF terminal is attached to the bridge closest to the host computer. However, RF terminals are constantly listening for HELLO and polling

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When a bridge receives a data packet from a terminal directed to the host computer, the bridge forwards the data packet to the parent node on the branch. The parent node then forwards the data packet to its parent node. The forwarding of the data packet continues until the gateway root node receives the data packet and sends it to the host computer. Similarly, when a packet arrives at a node from the host computer directed to an RF terminal, the node checks its routing entry table and forwards the data packet to its child node which is along the branch destined for the RF terminal. It is not necessary for the nodes along the branch containing the RF terminal to know the ultimate location of the RF terminal. The forwarding of the data packet continues until the data packet reaches the final node on the branch, which

then forwards the data packet directly to the terminal itself.

5 Communication is also possible between RF terminals. To communicate with another RF terminal, the RF terminal sends a data packet to its attached bridge. When the bridge receives the data packet from a terminal directed to the host computer, the bridge checks to see if the destination address of the RF terminal is located within its routing table. If it is, the bridge simply sends the message to the intended RF terminal. If not, the bridge forwards the data packet to its parent node. The forwarding of the data packet up the branch continues until a common parent between the RF terminals is found. Then, the common parent (often the gateway node itself) sends the data packet to the intended RF terminal via the branches of the RF Network.

15 During the normal operation of the RF Network, RF terminals can become lost or unattached to their attached node. If an RF terminal becomes unattached, for whatever reason, its routing entry is purged and the RF terminal listens for HELLO or polling messages from any attached nodes in range. After receiving HELLO or polling messages from attached nodes, the RF terminal sends an ATTACH.request packet to the attached node closest to the root. That attached node acknowledges the ATTACH.request and sends the ATTACH.request packet onto the gateway root node. Then, the gateway root node returns an end-to-end ATTACH.confirm packet.

25 Bridges can also become lost or unattached during normal operations of the RF Network. If a bridge becomes lost or unattached, all routing entries containing the bridge are purged. The bridge then broadcasts a HELLO.request with a global bridge

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destination address. Attached nodes will broadcast HELLO packets immediately if they receive an ATTACH.request packet with a global destination address. This helps the lost node re-attach. Then,
5 the bridge enters the LISTEN state to learn which attached nodes are within range. The unattached bridge analyzes the contents of broadcast HELLO messages to determine whether to request attachment to the broadcasting node. Again, the bridge attempts to
10 attach to the node that is logically closest to the root node. After attaching to the closest node, the bridge begins broadcasting HELLO messages to solicit ATTACH.requests from other nodes or RF terminals.

The spread-spectrum system provides a
15 hierarchical radio frequency network of on-line terminals for data entry and message transfer in a mobile environment. The network is characterized by sporadic data traffic over multiple-hop data paths consisting of RS485 or ethernet wired links and
20 single-channel direct sequenced spread spectrum links. The network architecture is complicated by moving, hidden, and sleeping nodes. The spread spectrum system consists of the following types of devices:

Terminal controller -- A gateway which passes
25 messages from a host port to the RF network; and which passes messages from the network to the host port. The host port (directly or indirectly) provides a link between the controller and a "host" computer to which the terminals are logically attached.

30 Base station -- An intermediate relay node which is used to extend the range of the controller node. Base station-to-controller or base station-to-base station links can be wired or wireless RF.

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Terminal -- Norand RF hand-held terminals, printers, etc. In addition, a controller device has a terminal component.

5 The devices are logically organized as nodes in an (optimal) spanning tree, with the controller at the root, internal nodes in base stations or controllers on branches of the tree, and terminal nodes as (possibly mobile) leaves on the tree. Like a sink tree, nodes closer to the root of the spanning tree
10 are said to be "downstream" from nodes which are further away. Conversely, all nodes are "upstream" from the root. Packets are only sent along branches of the spanning tree. Nodes in the network use a "BACKWARD LEARNING" technique to route packets along
15 the branches of the spanning tree.

Devices in the spanning tree are logically categorized as one of the following three node types:

1) Root (or root bridge) - A controller device which functions as the root bridge of the
20 network spanning tree. In the preferred embodiment, the spanning tree has a single root node. Initially, all controllers are root candidates from which a root node is selected. This selection may be based on the hopping
25 distance to the host, preset priority, random selection, etc.

2) Bridge - An internal node in the spanning tree which is used to "bridge" terminal nodes together into an interconnected network. The
30 root node is also considered a bridge and the term "bridge" may be used to refer to all non-terminal nodes or all non-terminal nodes except the root, depending on the context herein. A bridge node consists of a network interface
35 function and a routing function.

3) Terminal - leaf node in the spanning tree. A terminal node can be viewed as the software entity that terminates a branch in the spanning tree.

5 A controller device contains a terminal node(s) and a bridge node. The bridge node is the root node if the controller is functioning as the root bridge. A base station contains a bridge node. A terminal device contains a terminal node and must have a
10 network interface function. A "bridging entity" refers to a bridge node or to the network interface function in a terminal.

The basic requirements of the system are the following.

- 15 a) Wired or wireless node connections.
b) Network layer transparency.
c) Dynamic/automatic network routing configuration.
d) Terminal mobility. Terminals should be able
20 to move about the RF network without losing an end-to-end connection.
e) Ability to accommodate sleeping terminals.
f) Ability to locate terminals quickly.
g) Built-in redundancy. Lost nodes should have
25 minimal impact on the network.
h) Physical link independence. The bridging algorithm is consistent across heterogeneous physical links.

The software for the spread-spectrum system is
30 functionally layered as follows.

Medium Access Control (MAC)

The MAC layer is responsible for providing
reliable transmission between any two nodes in the
35 network (i.e. terminal-to-bridge). The MAC has a

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channel access control component and a link control component. The link control component facilitates and regulates point-to-point frame transfers in the absence of collision detection. The MAC channel
5 access control component regulates access to the network. Note that herein, the MAC layer is also referred to as the Data Link layer.

Bridging Layer

10 The bridging layer, which is also referred to herein as the network layer, has several functions as follows.

1. The bridging layer uses a "HELLO protocol" to organize nodes in the network into an optimal spanning tree rooted at the root bridge. The spanning
15 tree is used to prevent loops in the topology. Interior branches of the spanning tree are relatively stable (i.e. controller and relay stations do not move often). Terminals, which are leaves on the spanning
20 three, may become unattached, and must be reattached, frequently.

2. The bridging layer routes packets from terminals to the host, from the host to terminals, and from terminals to terminals along branches of the
25 spanning tree.

3. The bridging layer provides a service for storing packets for SLEEPING terminals. Packets which cannot be delivered immediately can be saved by the bridging entity in a parent node for one or more HELLO
30 times.

4. The bridging layer propagates lost node information throughout the spanning tree.

5. The bridging layer maintains the spanning tree links.

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6. The bridging layer distributes network interface addresses.

Logical Link Control Layer

5 A logical link control layer, also known herein
as the Transport layer herein, is responsible for
providing reliable transmission between any two nodes
in the network (i.e., terminal-to-base station). The
data-link layer provides a connection-oriented
10 reliable service and a connectionless unreliable
service. The reliable service detects and discards
duplicate packets and retransmits lost packets. The
unreliable services provides a datagram facility for
upper layer protocols which provide a reliable end-to-
15 end data path. The data-link layer provides ISO layer
2 services for terminal-to-host application sessions
which run on top of an end-to-end terminal-to-host
transport protocol. However, the data-link layer
provides transport (ISO layer 4) services for sessions
20 contained within the SST network.

Higher Layers

For terminal-to-terminal sessions contained
within the SST network, the data-link layer provides
25 transport layer services and no additional network or
transport layer is required. In this case, the MAC,
bridging, and data-link layers discussed above can be
viewed as a data-link layer, a network layer, and a
transport layer, respectively. For terminal-to-host-
30 application sessions, higher ISO layers exist on top
of the SST data-link layer and must be implemented in
the terminal and host computer, as required. This
document does not define (or restrict) those layers.
This document does discuss a fast-connect VMTP-like

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transport protocol which is used for transient internal terminal-to-terminal sessions.

Specifically, a network layer has several functions, as follows.

5 1) The network layer uses a "hello protocol" to organize nodes in the network into an optimal spanning tree rooted at the controller. (A spanning tree is required to prevent loops in the topology.) Interior branches of the spanning tree are relatively stable
10 (i.e., the controller and base stations do not move often). Terminals, which are leaves on the spanning tree, become unattached, and must be reattached frequently.

15 2) The network layer routes messages from terminals to the host, from the host to terminals, and from terminals to terminals along branches of the spanning tree.

20 3) The network layer provides a service for storing messages for SLEEPING terminals. Messages which cannot be delivered immediately can be saved by the network entity in a parent node for one or more hello times.

 4) The network layer propagates lost node information throughout the spanning tree.

25 5) The network layer maintains the spanning tree links in the absence of regular data traffic.

 A transport layer is responsible for establishing and maintaining a reliable end-to-end data path between transport access points in any two nodes in
30 the network. The transport layer provides unreliable, reliable and a transaction-oriented services. The transport layer should be immune to implementation changes in the network layer.

 The responsibilities of the transport layer
35 include the following.

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1) Establishing and maintaining TCP-like connections for reliable root-to-terminal data transmission.

5 2) Maintaining VMTP-like transaction records for reliable transient message passing between any two nodes.

3) Detecting and discarding duplicate packets.

4) Retransmitting lost packets.

10 Layers 1 through 4 are self-contained within the Norand RF network, and are independent of the host computer and of terminal applications. The session layer (and any higher layers) are dependent on specific applications. Therefore, the session
15 protocol (and higher protocols) must be implemented as required. Note that a single transport access point is sufficient to handle single sessions with multiple nodes. Multiple concurrent sessions between any two nodes could be handled with a session identifier in a session header.

20 Network address requirements are as follows. DLC framed contain a hop destination and source address in the DLC header. network packets contain an end-to-end destination and a source address in the network header. Transport messages do not contain an address
25 field; instead, a transport connection is defined by network layer source and destination address pairs. Multiple transport connections require multiple network address pairs.

30 The transport header contains a TRANSPORT ACCESS POINT identifier. DLC and network addresses are consistent and have the same format. Each node has a unique LONG ADDRESS which is programmed into the node at the factory. The long address is used only to obtain a SHORT ADDRESS from the root node.

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The network entity in each node obtains a SHORT ADDRESS from the root node, which identifies the node uniquely. The network entity passes the short address to the DLC entity. Short addresses are used to minimize packet sizes.

Short addresses consist of the following. There is: an address length bit (short or long).

a spanning tree identifier.

a node-type identifier. Node types are well known.

a unique multi-cast or broadcast node identifier.

The node-identifier parts of root addresses are well known and are constant. A default spanning tree identifier is well known by all nodes. A non-default spanning tree identifier can be entered into the root node (i.e., by a network administrator) and advertised to all other nodes in "hello" packets. The list of non-default spanning trees to which other nodes can attach must be entered into each node.

A node-type identifier of all 1's is used to specify all node types. A node identifier of all 1's is used to specify all nodes of the specified type. A DLC identifier of all 0's is used to specify a DLC entity which does not yet have an address. The all-0's address is used in DLC frames that are used to send and receive network ADDRESS packets. (The network entity in each node filters ADDRESS packets based on the network address.)

Short-address allocation is accomplished as follows. Short node identifiers of root nodes are well known. All other nodes must obtain a short node identifier from the root. To obtain a short address, a node send an ADDRESS request packet to the root node. The source addresses (i.e., DLC and network) in the request packet are LONG ADDRESSES. The root

maintains an address queue of used and unused SHORT ADDRESSES. If possible, the root selects an available short address, associates the short address with the long address of the requesting node, and returns the short address to the requesting node in an ADDRESS acknowledge packet. (Note that the destination address in the acknowledge packet is a long address.)

A node must obtain a (new) short address initially and whenever an ADDRESS-TIMEOUT inactivity period expires without having the node receive a packet from the network entity in the root.

The network entity in the root maintains addresses in the address queue in least recently used order. Whenever a packet is received, the source address is moved to the end of the queue. The address at the head of the queue is available for use by a requesting node if it has never been used or if it has been inactive for a MAX-ADDRESS-LIFE time period.

MAX-ADDRESS-LIFE must be larger than ADDRESS-TIMEOUT to ensure that an address is not in use by any node when it becomes available for another node. If the root receives an ADDRESS request from a source for which an entry exists in the address queue, the root simply updates the queue and returns the old address.

The network layer organizes nodes into an optimal spanning tree with the controller at the root of the tree. (Note that the spanning tree identifier allows two logical trees to exist in the same coverage area.) Spanning tree organization is facilitated with a HELLO protocol which allows nodes to determine the shortest path to the root before attaching to the spanning tree. All messages are routed along branches of the spanning tree.

Nodes in the network are generally categorized as ATTACHED or UNATTACHED. Initially, only the root node

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is attached. A single controller may be designated as the root, or multiple root candidates (i.e. controllers) may negotiate to determine which node is the root. Attached bridge nodes and root candidates transmit "HELLO" packets at calculated intervals. The HELLO packets include:

a) the source address, which includes the spanning tree ID).

b) a broadcast destination address.

c) a "seed" value from which the time schedule of future hello messages can be calculated.

d) a hello slot displacement time specifying an actual variation that will occur in the scheduled arrival of the very next hello message (the scheduled arrival being calculated from the "seed").

e) the distance (i.e., path cost) of the transmitter from the host. The incremental portion of the distance between a node and its parent is primarily a function of the type of physical link (i.e., ethernet, RS485, RF, or the like). If a signal-strength indicator is available, connections are biased toward the link with the best signal strength. The distance component is intended to bias path selection toward (i.e., wired) high-speed connections. Setting a minimum signal strength threshold helps prevent sporadic changes in the network. In addition, connections can be biased to balance the load (i.e., the number of children) on a parent node.

f) a pending message list. Pending message lists consist of 0 or more destination-address/message-length pairs. Pending messages for terminals are stored in the terminal's parent node.

g) a detached-node list. Detached-node lists contain the addresses of nodes which have detached

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DELETING INVALID ROUTING TABLE ENTRIES is accomplished in several ways: connection oriented transport layer ensures that packets will arrive from nodes attached to the branch of the spanning tree within the timeout period, unless a node is disconnected.)

2) Whenever the DLC entity in a parent fails RETRY MAX times to send a message to a child node, the node is logically disconnected from the spanning tree, with one exception. If the child is a SLEEPING terminal, the message is retained by the network entity in the parent for "count" hello times. The parent immediately attempts to deliver the message after it sends its next hello packet. If, after "count" hello times, the message cannot be delivered, then the child is logically detached from the spanning tree. Detached node information is propagated downstream to the root node, each node in the path of the DETACH packet must adjust its routing tables appropriately according to the following rules: a) if the lost node is a child terminal node, the routing entry for the terminal is deleted and a DETACH packet is generated, b) if the node specified in DETACH packet is a terminal and the node which delivered the packet is the next hop in the path to the terminal, then the routing table entry for the terminal is deleted and the DETACH packet is forwarded, c) if the lost node is a child base station node then all routing entries which specify that base station as the next hop are deleted and a DETACH packet is generated for each lost terminal.

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6) A node enters the ATTACHED LISTEN state whenever a single hello message, from its parent, is missed. SLEEPING terminals remain awake during the ATTACHED LISTEN state. The state ends when the terminal receives a data or hello message from its parent. The terminal becomes UNATTACHED when a) its address appears in the detached list of a hello message from an ode other than its parent, or b) HELLO-RETRY-MAX hello messages are missed. The total number of hello slots spend in the LISTEN state is constant.

If a node in the ATTACHED LISTEN state discovers a path to the root which is CHANGE-THRESHOLD shorter, it can attach to the shorter path. Periodically, SLEEPING terminals must enter the ATTACHED LEARN state to discovery any changes (i.e., shorter paths) in the network topology.

Hello synchronization.

All attached non-terminal nodes broadcast periodic "hello" messages in discrete "hello slots" at calculated intervals. Base station nodes learn which hello slots are busy and refrain from transmitting during busy hello slots.

A terminal refrains from transmitting during the hello slot of its parent node and refrains from transmitting during message slots reserved in a hello message.

The hello message contains a "seed" field used in a well-known randomization algorithm to determine the next hello slot for the transmitting node and the next seed. The address of the transmitting node is used as a factor in the algorithm to guarantee randomization. Nodes can execute the algorithm i times to determine

the time (and seed) if the i-th hello message from the transmitter.

5 After attached, a base station chooses a random initial seed and a non-busy hello slot and broadcasts a hello message in that slot. The base station chooses succeeding hello slots by executing the randomization algorithm. If an execution of the algorithm chooses a busy slot, the next free slot is used and a hello "displacement" field indicates the
10 offset from a calculated slot. Cumulative delays are not allowed (i.e., contention delays during the i hello transmission do not effect the time of the i+1 hello transmission).

15 HELLO-TIME and HELLO-SLOT-TIME values are set by the root node and flooded throughout the network in hello messages. The HELLO-SLOT-TIME value must be large enough to minimize hello contention.

20 A node initially synchronizes on a hello message from its parent. A SLEEPING node can power-down with an active timer interrupt to wake it just before the next expected hello message. The network entity in base station nodes can store messages for SLEEPING nodes and transmit them immediately following the hello messages. This implementation enables SLEEPING
25 terminals to receive unsolicited messages. (Note that the network layer always tries to deliver messages immediately, before storing them.) Retries for pending messages are transmitted in a round-robin order when messages are pending for more than one
30 destination.

Note that a child node that misses i hello messages, can calculate the time of the i+1 hello message.

35 Transport layer theory and implementation notes.

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The transport layer provides reliable, unreliable, and transaction-oriented services. Two types of transport connections are defined: 1) a TCP-like transport connection may be explicitly requested for long-lived connections or 2) a VMTP-like connection-record may be implicitly set up for transient connections. In addition, a connectionless service is provided for nodes which support an end-to-end transport connection with the host computer.

The interfaces to the next upper (i.e., application) layer include:

CONNECT (access_point, node_name)

LISTEN (access_point)

UNITDATA (access_point, node_name, buffer, length)

SEND (handle, buffer, length)

RECEIVE (handle, buffer, length)

CLOSE (handle)

The "handle" designates the connection type, and is the connection identifier for TCP-like connections.

SEND messages require a response from the network node (root or terminal) to which the message is directed.

UNITDATA messages do not require a response. UNITDATA is used to send messages to a host which is capable of supporting end-to-end host-to-terminal transport connections.

Because the network layer provides an unreliable service, the transport layer is required to detect duplicate packets and retransmit lost packets. Detecting duplicates is facilitated by numbering transport packets with unambiguous sequence numbers.

Transport connections.

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response message. Note that missed messages may be stored by the network layer for "count" hello times.

Medium Access Control (MAC) theory and implementation notes.

Access to the network communications channel is regulated in several ways: executing the full CSMA algorithm (see MAC layer above). The sender retransmits unacknowledged messages until a RETRY_MAX count is exhausted.

The retry time of the DLC must be relatively short so that lost nodes can be detected quickly. When the DLC layer reports a failure to deliver a message to the network layer, the network layer can 1) save messages for SLEEPING terminals for later attempts, or 2) DETACH the node from the spanning tree. Note that most lost nodes are due to moving terminals.

The node identifier part of the DLC address is initially all 0's for all nodes except the root node. The all 0's address is used by a node to send and received data-link frames until a unique node identifier is passed to the DLC entity in the node. (The unique node identifier is obtained by the network entity.)

Address resolution.

Well-known names too are bound to network addresses in several ways:

- The network address and TRANSPORT ACCESS ID of a name server, contained in the root, is well-known by all nodes.

- A node can register a well-known name with the name server contained in the root node.

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In a preferred embodiment, the data to be sent through the RF communication link is segmented into a plurality of DATA packets and is then transmitted. Upon receipt, the DATA packets are reassembled for use or storage. Data segmentation of the RF link provides

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better communication channel efficiency by reducing the amount of data loss in the network. For example, because collisions between transmissions on an RF link cannot be completely avoided, sending the data in
5 small segments results in an overall decrease in data loss in the network, i.e., only the small segments which collide have to be re-sent.

Similarly, choosing smaller data packets for transmission also reduces the amount of data loss by
10 reducing the inherent effects of perturbations and fluctuations found in RF communication links. In particular, RF signals are inherently subject to what is termed "multi-path fading." A signal received by a receiver is a composite of all signals that have
15 reached that receiver by taking all available paths from the transmitter. The received signal is therefore often referred to as a "composite signal" which has a power envelope equal to the vector sum of the individual components of the multi-path signals
20 received. If the signals making up the composite signal are of amplitudes that add "out of phase", the desired data signal decreases in amplitude. If the signal amplitudes are approximately equal, an effective null (no detectable signal at the receiver)
25 results. This condition is termed "fading".

Normally changes in the propagation environment occur relatively slowly, i.e., over periods of time ranging from several tenths (1/10's) of seconds to several seconds. However, in a mobile RF environment,
30 receivers (or the corresponding transmitters) often travel over some distance in the course of receiving a message. Because the signal energy at each receiver is determined by the paths that the signal components take to reach that receiver, the relative motion
35 between the receiver and the transmitter causes the

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Additionally, instead of using a true randomization, a pseudo-random offset is used which bases all pseudo-random offset calculations on a seed value (the "seed"). The "seed" is broadcast in each HELLO message so that the timing of the next HELLO message may be calculated by any listening mobile terminal. The use of the seed, and pseudo random offset generation, allows the terminal to "sleep" (enter an energy and CPU saving mode) between HELLO messages and be able to "wake up" (dedicate energy and CPU concentration on RF reception) and stay awake for the minimal time needed to receive the next HELLO message. The relationship between the time that a base station must remain awake to the time it may sleep is called the "duty cycle".

Using a 2 second HELLO to HELLO message timing with a pseudo-random offset range of +/- 1/3 of a second, the preferred embodiment has achieved a very

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1. A multi-hop data communication network having RF capability comprising:

2. The multi-hop data communication system of claim 1 further comprising means for offsetting the time period between HELLO message broadcasts.

3. The multi-hop data communication system of claim 2 further comprising means for calculating the time period between HELLO message broadcasts to be received.

4. The multi-hop data communication system of claim 3 wherein said means for offsetting further comprising a first pseudo-random number generator for generating an offset.

5. The multi-hop data communication system of claim 4 wherein said means for calculating further

comprising a second pseudo-random number generator used for computing the offset.

5 6. The multi-hop data communication system of claim 5 further comprising means for passing a seed value between said means for offsetting and said means for calculating so as to synchronize said first and second pseudo-random number generators.

7. A multi-hop data communication system having RF capability comprising:
a plurality of terminal nodes;
a plurality of bridging nodes; and
5 said bridging nodes further comprising, means for maintaining communication pathways between any two nodes in the network by repeatedly broadcasting messages identifying itself, means for determining the timing between the identifying message broadcasts.

8. The multi-hop data communication system of claim 7 wherein said terminal nodes further comprising means for calculating the time period between HELLO message broadcasts to be received.

9. The multi-hop data communication system of claim 8 wherein the means for determining the timing and the means for calculating the time both further comprise pseudo-random number generator using
5 a common seed value.

10. The multi-hop data communication system of claim 9 further comprising means for passing a seed value between said means for determining the timing and the means for calculating the time.

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5 a RF transceiver;
 means for segmenting digitally encoded data to be
transferred into discrete data packets;
 means responsive to said segmenting means for
individually transmitting each discrete data packet;
10 and
 means for reconstructing discrete data packets
into digitally encoded data.

12. The multi-hop data communication network of claim 11 wherein said terminal nodes further comprise means for digitally encoding voice signals, and means for generating audio signals from digitally encoded voice signals.

13. The multi-hop data communication network of claim 11 wherein the length of said discrete data packets are chosen based on correlation distance.

14. The multi-hop data communication network of claim 12 wherein the length of said discrete data packets are chosen based on correlation distance.

An apparatus and a method for routing data in a radio data communication system having one or more host computers, one or more intermediate base stations, and one or more RF terminals organizes the intermediate base stations into an optimal spanning-tree network to control the routing of data to and from the RF terminals and the host computer efficiently and dynamically. Communication between the host computer and the RF terminals is achieved by using the network of intermediate base stations to transmit the data.

FIG. 1

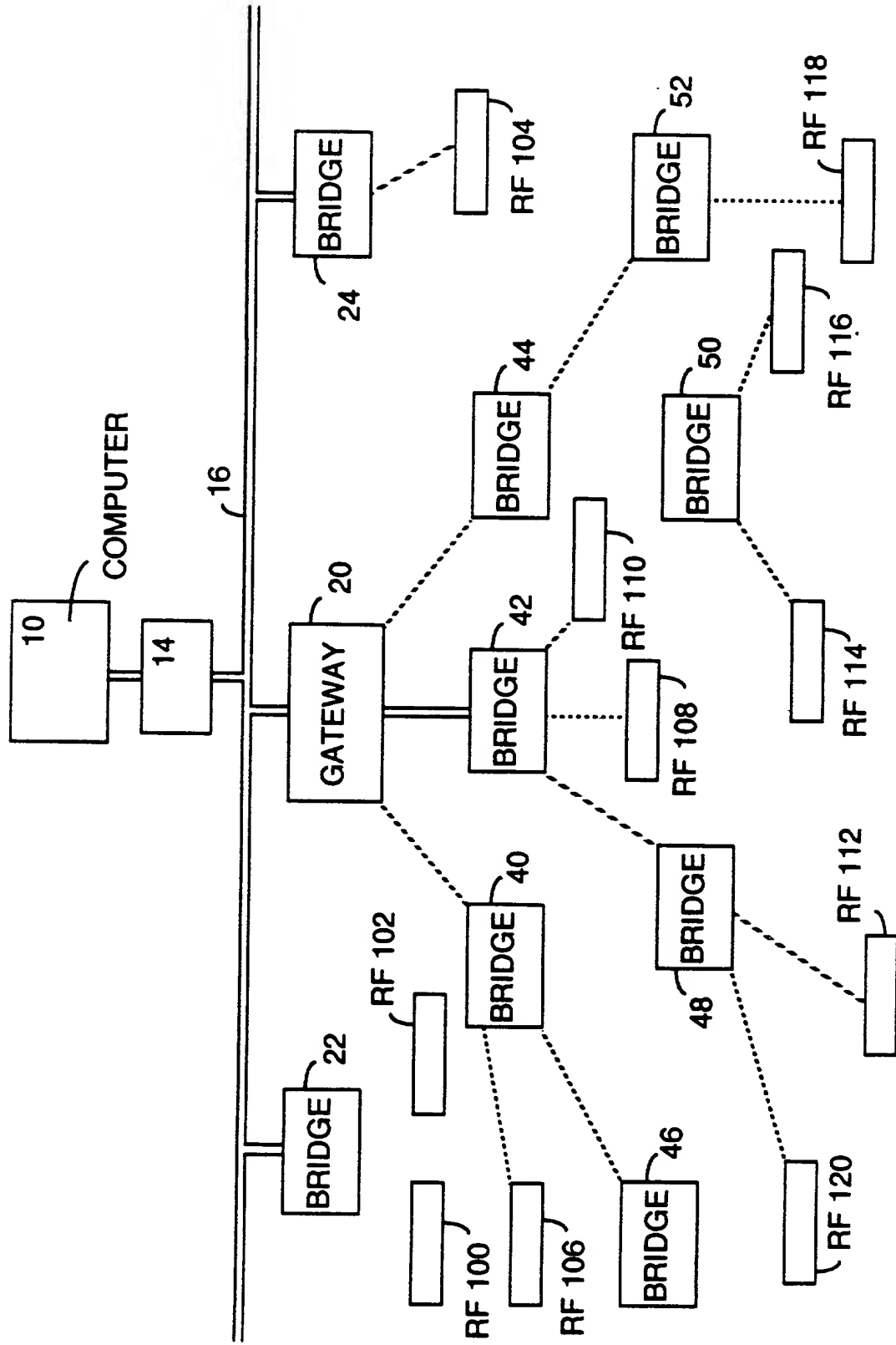
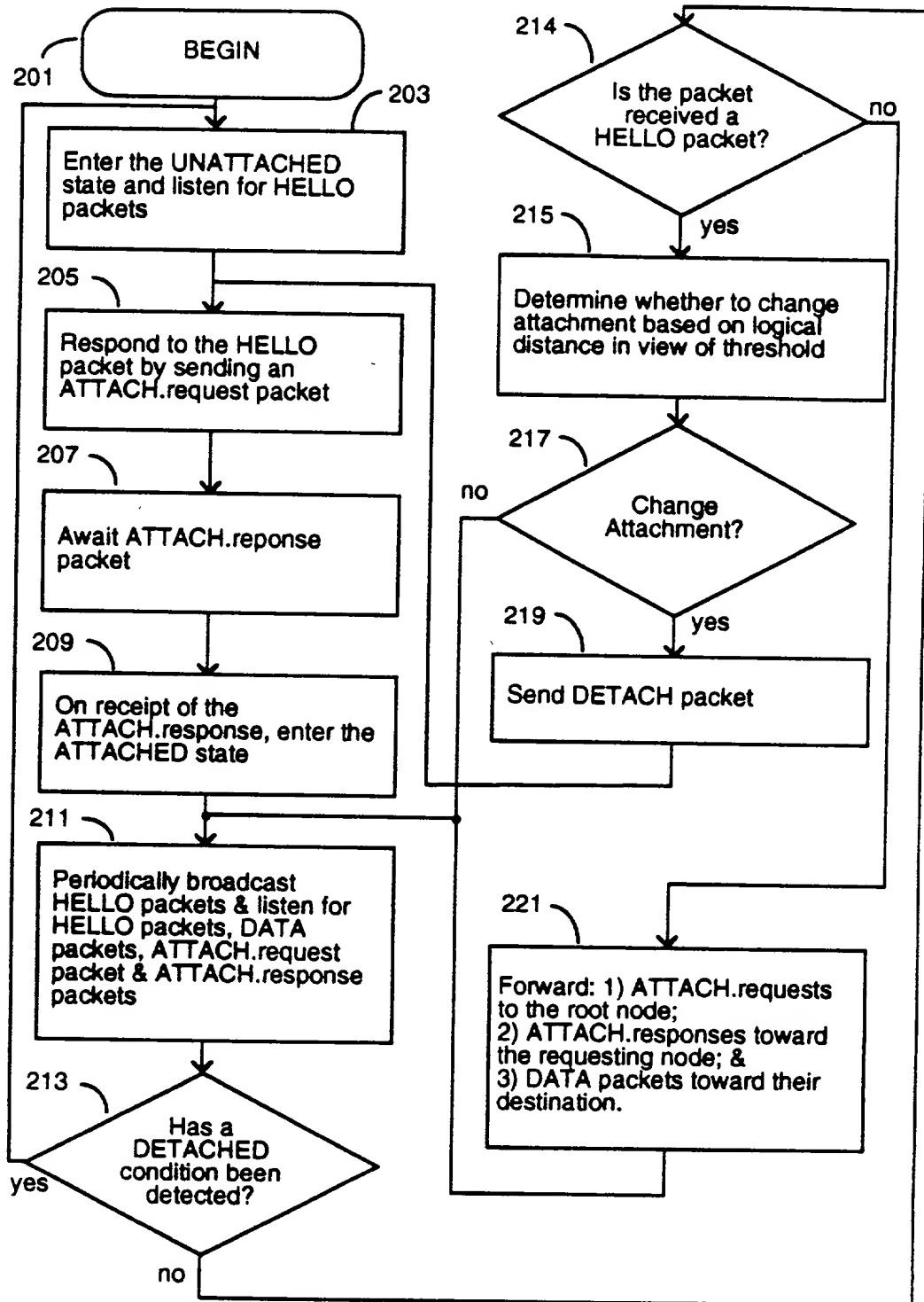


FIG. 2



CONTINUATION-IN-PART DECLARATION AND
POWER OF ATTORNEY IN PATENT APPLICATION

As a below named inventor, I hereby declare that my residence, post office address and citizenship are stated below next to my name; that I believe that I am the original and joint first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"RADIO FREQUENCY LOCAL AREA NETWORK"

described and claimed in the attached specification herewith, or as filed on November 2, 1992, as U.S. Serial No. 07/970,411.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose all information known to me to be material to patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119, of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

<u>Prior Foreign Application(s)</u>	<u>Priority Claimed</u>
PCT/US92/08610 PCT October 1, 1992	<u>X</u> Yes <u> </u> No

CLAIM FOR BENEFIT OF EARLIER U.S./PCT
APPLICATION(S) UNDER 35 U.S.C. 120

I hereby claim the benefit under Title 35, United States Code, Section 120, of any United States applications that are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in those prior applications in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56, which occurred between the filing date of the prior applications and the filing date of this application:


PRIOR U.S. APPLICATIONS FOR
WHICH BENEFIT IS CLAIMED UNDER 35 U.S.C. 120

	<u>U.S. Serial No.</u>	<u>U.S. Filing Date</u>	<u>Named Inventors</u>
(1)	07/699,818 (Attorney Docket No. 37834)	5/13/91	R. Luse, R. Mahany, et al
(2)	07/700,704 (Attorney Docket No. 37834X)	5/14/91	R. Luse, R. Mahany, et al
(3)	07/769,425 (Attorney Docket No. 37882)	10/1/91	R. Meier, R. Luse, et al
(4)	07/790,946 (Attorney Docket No. 91P1130)	11/12/91	R. Meier
(5)	07/802,348 (Attorney Docket No. 91P1189)	12/4/91	R. Meier
(6)	07/857,603 (Attorney Docket No. 92P327)	3/30/92	R. Luse, R. Mahany, et al
(7)	07/907,927 (Attorney Docket No. 92P461)	6/30/92	R. Luse, R. Mahany, et al
(8)	07/947,102 (Attorney Docket No. 92P498)	9/14/92	R. Luse, R. Mahany, R. Meier, et al
(9)	 (Attorney Docket No. 92P758)	10/30/92	R. Meier, R. Luse

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date

03 JANUARY 1993


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